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RESEARCH

Cost-Effectiveness of In-House Versus Contracted-Out Vision Rehabilitation Services in England

Francesco Longo, Pedro Saramago, Helen Weatherly, Parvaneh Rabiee, Yvonne Birks, Ada Keding and Illary Sbizzera

Context: Vision rehabilitation (VR) services in England promote users' health and wellbeing, and support all aspects of daily living through two dominant models: in-house and contracted-out VR services. The two models differ in terms of service delivery, but they share a common aim to enhance service users' quality of life and reduce utilisation of social and health care services.
Objective: This study investigated the cost-effectiveness of in-house versus contracted-out VR services.
Methods: The analysis was performed from a social care perspective and a social and health care perspective. The analyses used data from a six-month follow-up observational study of VR users. Regression analysis was used to estimate differential outcomes and costs, taking user and local authority characteristics into account.
Findings: At a cost-effectiveness threshold of £13,000 and £30,000 per QALY, in-house VR services have a high probability (greater than 90% vs. contracted-out VR services) of being cost-effective from a social care perspective. In-house VR services have a lower probability (lower than 25% vs. contracted-out VR services) of being cost-effective from a social and health care perspective.
Limitations: Observational studies are prone to selection bias compared to randomised controlled trials due to confounding. We employed econometric techniques that control for several user and LA characteristics to reduce potential bias.
Implications: Contracted-out VR services may be better value for money compared to in-house VR services in the context of integrated social and health care due to substantial healthcare resource savings.

Keywords: social care; vision rehabilitation; economic evaluation; health care; quality-adjusted life years (QALY); care-related quality of life

1. Introduction

Vision impairment, or sight loss, is particularly prevalent in older people and can impact wellbeing, including activities of daily living (e.g., getting in and out of the bed, ambulating) and mental health (Rabiee et al., 2016). The World Health Organisation (WHO) estimates that no less than 2.2 billion people (i.e., 28.6% of the world population in 2019) live with some form of vision impairment and that at least 45% of these people may have their vision impairment prevented or addressed (World Health Organization, 2018). In 2013, the World Health Assembly produced a global action plan 2014–19 to support the use of more and better prevention and rehabilitation services for individuals with vision impairment across multiple sectors of the economy (World Health Organization, 2013). This plan has stimulated rapid growth of vision rehabilitation (VR) services, which aim to promote independence and to prevent crisis. VR services aim to improve quality of life and reduce the demand for social care and health care services (Rabiee et al., 2015).

Across countries, different models of VR services exist, including clinic-based, community-based, and multidisciplinary VR services (Alma et al., 2012; Rees et al., 2013; Fontenot et al., 2018), and it is not clear which approach offers the best value for money. Clinic-based VR services focus on use of health care services (e.g., eye surgery) to reduce visual impairment, whilst community-based VR services aim to reduce the broader impact of vision impairment on activities of daily living, safety, and social life. Multidisciplinary VR services provide a mix of clinic- and community-based services.

The evidence about the effects of VR services is increasing. A systematic review by Binns et al. (2012) suggested that VR improved clinical and functional ability outcomes; however, clear conclusions were not drawn about its effects on vision-related quality of life, which is a condition-specific outcome (Angeles-Han et al., 2011), nor generic health-related quality of life (HRQoL). Broader outcomes such as generic care-related quality of life

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(CRQoL), which captures the impact of social care services on quality of life, were not covered (Netten et al., 2011; Netten et al., 2012). Two cost-consequence studies were included in the review. Eklund et al. (2005) explored the effect on perceived level of security and costs of a group-based health education programme for people with age-related macular degeneration compared to an individual-based programme in Sweden. The group-based health education programme increased users' level of security and reduced costs compared to the individual-based programme. Stroupe et al. (2008) analysed the impact on functional ability and costs of an outpatient rehabilitation programme versus residential rehabilitation for blind veterans in the US. The outpatient rehabilitation programme had a weaker effect on users' functional ability but also lower costs. Neither study formally examined the cost-effectiveness of interventions. More recently, Rabiee et al. (2015) suggested that community-based VR services may have a beneficial effect on activities of daily living and psychological outcomes but found no evidence on cost-effectiveness.

The present study focuses on community-based VR services in England. However, many other countries, such as Australia (Matti et al., 2011; Rees et al., 2013), Netherlands (Langelaan et al., 2009; Alma et al., 2012), and US (Ekin, 2005; Jones et al., 2009) provide similar services and, therefore, this study might have broader relevance. In the UK, almost two million people (3% of the UK population, 2019) live with vision impairment, and this figure is forecasted to more than double by 2050 (RNIB, 2013). The Care Act 2014 (UK Parliament, 2014) has emphasised the vital role that community-based VR services offer in supporting visually impaired people and in reducing demand pressures on public services such as the NHS. In England, 145 of the 152 local authorities (LAs) with responsibilities for adult social care are known to deliver community-based VR services (Rabiee et al., 2015). One hundred thirty-seven (94%) of these 145 LAs provide VR services through two dominant models which are the focus of this study: in-house (71% of LAs) and contracted-out (23% of LAs) VR services although, in practice, the picture is more mixed (Rabiee et al., 2015: 81).

In-house VR services are funded and delivered directly by LAs, while contracted-out VR services are funded by LAs but they are delivered by external organisations. All individuals having difficulty with activities of daily living related to sight loss are potentially eligible for these VR services and most are free-of-charge (Rabiee et al., 2015).[1] Both in-house and contracted-out VR services are goal driven short-term services and their effects are intended to be relatively immediate on VR users' activities of daily living and independence. Generally, both services consist of specialist vision impairment services such as training in independent living skills (e.g., dressing, cooking), orientation and mobility (e.g., shopping, going out with friends), and use of aids, adaptations, and equipment (e.g., liquid level indicators, talking labeller devices). LAs and external organisations, however, differ in terms of remit. LAs employ teams which often carry out wider sensory impairment work, usually vision and hearing rehabilitation and often additional generic work (e.g., arranging social care, advising on benefits, mental health services) either through the rehabilitation officer or through referral to other LA services, whereas external organisations generally employ teams which solely focus on VR. Therefore, in-house VR services tend to include a broader range of services, while contracted-out organisations tend to allocate more resources to sight loss specific group activities (e.g., social events, leisure activities).

Although there are substantial differences in the delivery of these two models of community-based VR, no evidence exists to inform the choice about which model to invest in. This study investigated the cost-effectiveness of in-house versus contracted-out VR services in England using a six-month follow-up, observational study of VR users. Cost-effectiveness was examined from two perspectives comprising a social care perspective and a social and health care perspective. The latter covered the perspective of social care and health care decision makers combined. This is of interest because, in some areas of England, in-house and contracted-out VR models are provided within integrated social and health care systems.

2. Methods

2.1. Analysis perspectives

An economic evaluation of in-house and contracted-out VR services was undertaken from the (i) social care perspective and the (ii) social care and health care perspective combined. The social care perspective is relevant because in-house and contracted-out VR services are commissioned by LAs. LAs are key social care decision makers with an interest in the impact of VR on users' CRQoL, and on the use of other social care services they provide (e.g., residential care, community care). However, the social care and health care perspective is also relevant where LAs and the NHS pay for the service and are, therefore, the shared decision makers. From this perspective, CRQoL and HRQoL are key outcomes and the impact on social and health care resources is central.

2.2. Data sources

Data on VR user outcomes, resource use, and characteristics were collected through a survey administered in 2017 at four points in time: baseline and after one, two, and six months. A six-month time horizon was chosen because VR services typically aim to help users achieve their goals in no longer than eleven weeks (less than three months). This six-month study is therefore likely to capture the key effects of VR services, although further longer-term impacts cannot be excluded.

Nine in-house and nine contracted-out VR services were recruited on a self-selecting basis from an invitation sent to the 133 LAs known to deliver either in-house or contracted-out VR services only (see Section 1). VR services typically recruited eligible VR users upon their consent, via service managers. Eligible VR users included those who were newly referred to the service, or existing users if they experienced a major change in their circumstances and needs. Eligible participants were aged 18 and over, living in independent accommodation in the community, were not born blind and were able to speak and understand English. Data on outcomes and resource use were collected through telephone interviews conducted by the research team at baseline and after one, two, and six months. Data on user characteristics were collected at baseline by the VR services. In addition, we collected data on LA characteristics from the UK 2011 Census data (Office for National Statistics, 2012) which were used as additional control variables to account for potential sources of selection bias (see Section 2.5 and 2.5.1 for greater detail).

2.3. Social care- and health-related quality of life

To measure CRQoL, we used the Adult Social Care Outcomes Toolkit (ASCOT-SCT4) as recommended by the National Institute for Health and Care Excellence (NICE), for the economic evaluation of social care services (National Institute for Health Care Excellence, 2018). To measure HRQoL, we used the EQ-5D-5L, as also recommended by NICE (National Institute for Health Care Excellence, 2018). Both of these instruments are generic preference-based measures which describe and value care and health states respectively, for use in cost-effectiveness analyses and for making comparisons across interventions where these outcomes are relevant. More details about these instruments are included in Section A1 of the Appendix. To calculate social care quality-adjusted life years (SC-QALYs) using ASCOT, and health QALYS (H-QALYs) using EQ-5D-3L, the area under the curve method was used (Drummond et al., 2015). These scores were multiplied by time in state for three time periods: from baseline to month one (defined as month 1), from month one to month two (defined as month 2), and from month two to month six (defined as month 6).

2.4. Resource use and costs

The main analysis focused on the costs of those social and health care services most likely to be used by VR users, and of key interest to social and health care decision makers. The study expert advisory group informed this choice. Costs for the financial year 2016/7 were calculated at baseline, and month 1, 2, and 6 by multiplying the amount of resources used by relevant national unit costs (included in Table A1 of the Appendix). Since the resource use questionnaire included questions about the resource use in the past month (to reduce recall bias), costs at six months were multiplied by four to cover the period from month three to month six.

Social care costs for VR users included the running costs of VR, the cost of LA-provided home care, council day care, social service meals, social services appointments, and befriending and transport services. The running costs of VR were calculated by multiplying the unit cost of VR by the total number of hours of VR (number of sessions by the average length of each session). Health care costs for primary health care service use (GP, nurse, ophthalmologist, and occupational therapist appointments) and secondary health care service use (outpatient appointments, elective, day case and emergency admissions and their length, and emergency telephone line and ambulance services) were calculated.

2.5. Analytical approach

In the absence of randomisation of the VR users in this study, comparing unadjusted means across in-house and contracted-out VR services is likely to yield misleading conclusions due to selection bias. This form of endogeneity might arise at the LA level rather than at the user level. This is because LAs might self-select into one of the models of service depending on their demand- and supply-side characteristics. For example, those LAs with greater demand pressures due to a population with greater needs and unable to service such high demand might be more likely to contract-out VR services. In this scenario, service users would have no choice as to the model of VR service used since this decision had been made at the level of the LA. Therefore, if there are systematic differences between VR users this may reflect the LA choice to provide either in-house or contracted-out VR services. The analysis controls for observed factors that may bias the results through several covariates measured at both user and LA level.

2.5.1. Covariates

The key covariate of interest is a dummy indicating whether a user received in-house VR services (reference: contracted-out VR services). To control for potential confounding the analysis controls for individual user and LA characteristics. User characteristics were used to account for demand-side factors across LAs, while LA characteristics captured both LA demand- and supply-side factors. **Tables 1** and **2** include the full list of user-level and LA-level covariates, respectively. These covariates were controlled for in all our regressions.

2.5.2. Econometric specifications

The effect of in-house versus contracted-out VR on user outcomes and costs was estimated using panel data linear regressions:

$$y_{ijt} = \mu + \beta d_j + \delta' X_i + \phi' Z_j + \alpha_i + \kappa_j + \tau_t + \varepsilon_{ijt} \quad (1)$$

$$c_{ijt} = \eta + \gamma d_j + \theta' X_i + \rho' Z_j + \omega_i + \psi_j + \pi_t + \xi_{ijt} \quad (2)$$

where y_{ijt} was the outcome and c_{ijt} was the cost of patient i (=1,...,I) in LA j (=1,...,18) at time t (=month 1, 2, and 6), μ and η were the intercepts, d_j was a dummy taking a value of one if the user located in LA j providing in-house VR services or zero otherwise, X_i was a vector of time-invariant covariates measuring user characteristics (see Section 0), Z_j was a vector of user- and time-invariant covariates capturing LA characteristics (see Section 0), α_i and ω_i captured time-invariant unobserved heterogeneity at the user level (e.g., user's genetic makeup), κ_j and ψ_j captured time-invariant unobserved heterogeneity at the LA level (e.g., sense of community of the local population), τ_t and π_t included year dummies to capture time trends (e.g., seasonal effects), and ε_{it} and ξ_{it} were the error terms (assumed to be independent from each other).[2] We controlled for time-invariant covariates solely, because our analysis focused on a short time window of six months,

Table 1: Descriptive statistics of user characteristics at baseline.

User characteristic	All users		In-house		Contracted-out		In-house vs contracted-out	
	User	Mean	User	Mean	User	Mean	Diff	p-value
VR type (%)								
Contracted-out (ref)	230	50.9%	113	0.0%	117	100.0%		
In-house	230	49.1%	113	100.0%	117	0.0%		
Baseline outcomes and costs (£)								
Baseline ASCOT score	226	0.682	111	0.678	115	0.685	–0.006	0.780
Baseline EQ-5D score	230	0.552	113	0.556	117	0.548	0.008	0.804
Baseline social care costs	221	795	108	706	113	880	–174	0.448
Baseline social and health care costs	224	234	110	239	114	229	10	0.836
Age (%)								
Older than 65 years old	219	53.4%	105	51.4%	114	55.3%	–3.8%	0.570
Gender (%)								
Female	230	63.5%	113	64.6%	117	62.4%	2.2%	0.728
Ethnicity (%)								
Non-British white	221	10.9%	106	13.2%	115	8.7%	4.5%	0.282
Living situation (%)								
Living with someone else	224	62.5%	107	59.8%	117	65.0%	–5.1%	0.427
Nature of impairment (%)								
Acquired	230	58.3%	113	54.9%	117	61.5%	–6.7%	0.305
Congenital	230	2.2%	113	1.8%	117	2.6%	–0.8%	0.680
Other	230	13.0%	113	15.0%	117	11.1%	3.9%	0.376
Unknown	230	37.8%	113	40.7%	117	35.0%	5.7%	0.376
Other health conditions (%)								
Physical	230	67.8%	113	69.0%	117	66.7%	2.4%	0.702
Sensory	230	17.4%	113	16.8%	117	17.9%	–1.1%	0.821
Mental health	230	14.3%	113	21.2%	117	7.7%	13.5%	0.003***
Other	230	9.6%	113	10.6%	117	8.5%	2.1%	0.593
Unknown	230	20.9%	113	19.5%	117	22.2%	–2.8%	0.608
Users registered as visually impaired (%)								
Registered as blind (ref)	208	38.9%	101	40.6%	107	37.4%	3.2%	0.682
Registered as partially sighted	208	35.6%	101	36.6%	107	34.6%	2.1%	
Not registered although visually impaired	208	25.5%	101	22.8%	107	28.0%	–5.3%	
Previous use of VR (%)								
No	205	65.4%	100	63.0%	105	67.6%	–4.6%	0.487

VR = vision rehabilitation, User = number of VR users, Diff = mean difference between in-house and contracted-out VR users, p-value = p-value of the mean difference statistical test, ref = reference category.

Descriptive statistics were calculated using the available observations for each variable after excluding three outliers as described in Section 3.1.

To test mean differences, we used a bootstrapped t-test with 1,000 replications for continuous variables and chi-square test for dummy and categorical variables.

during which relevant user and LA characteristics were not expected to vary.

We estimated (1) and (2) by the generalised least square (GLS) random-effects (RE) estimator, and we clustered

Table 2: Descriptive statistics of LA characteristics.

LA characteristic	All Las					In-house		Contracted-out		In-house vs contracted-out	
	Prov	Mean	SD	Min	Max	Prov	Mean	Prov	Mean	Diff	p-value
Demand factors											
Total population (per 100 K individuals)	18	5.21	3.80	1.98	14.64	9	4.58	9	5.84	–1.27	0.464
Population density (individuals per Hectare)	18	19	24	1	85	9	20	9	18	2	0.856
Proportion of people of age 65 and over	18	15.6	3.9	6.7	21.6	9	15.5	9	15.7	–0.1	0.935
Deprivation											
Proportion of no deprived people (ref)	18	41.5	6.1	25.0	49.6	9	38.8	9	44.1	–5.3	0.050**
Proportion of people deprived in one domain	18	32.6	1.6	30.8	38.1	9	33.0	9	32.3	0.7	0.368
Proportion of people deprived in two domains	18	19.8	3.2	15.0	26.0	9	21.3	9	18.3	3.0	0.025**
Proportion of people deprived in three domains	18	5.6	2.0	3.0	10.0	9	6.3	9	4.9	1.4	0.127
Proportion of people deprived in four domains	18	0.5	0.3	0.3	1.3	9	0.6	9	0.5	0.1	0.320
Supply factors											
Type of LA (%)											
London (ref)	18	11.1%	32.3%	0	1	9	11.1%	9	11.1%	0.0%	0.446
Metropolitan	18	27.8%	46.1%	0	1	9	44.4%	9	11.1%	33.3%	
Non-Metropolitan	18	33.3%	48.5%	0	1	9	22.2%	9	44.4%	–22.2%	
Unitary	18	27.8%	46.1%	0	1	9	22.2%	9	33.3%	–11.1%	

LA = local authority, VR = vision rehabilitation, Prov = number of VR providers, SD = standard deviation, Diff = mean difference between in-house and contracted-out VR users, p-value = p-value of the mean difference statistical test.
To test mean differences, we used a boostrapped t-test with 1,000 replications for continous variables and chi-square test for dummy and categorical variables.
Data on all LA characteristics were collected from the UK 2011 Census (http://infuse.ukdataservice.ac.uk/).

standard errors at the LA level to account for heteroscedasticity and autocorrelation within LAs.[3] We also implemented multiple imputation chained equations (MICE), as detailed in Table A2 of the Appendix, and run the analysis under the missing at random (MAR) assumption (Van Buuren et al., 1999; Carpenter and Kenward, 2012). The key coefficient of interest was $\hat{\beta}$ in (1) and $\hat{\gamma}$ in (2). If $\hat{\beta} > 0$ ($\hat{\gamma} > 0$) then users of in-house VR services had, on average, greater outcomes (costs) compared to users of contracted-out VR services.

2.5.3. Cost-effectiveness analysis

Cost-effectiveness was evaluated using the incremental net health benefit (INHB) as follows (Drummond et al., 2015: 299):

$$INHB = \hat{\beta} - \frac{\hat{\gamma}}{\lambda} \tag{3}$$

where $\hat{\beta}$ and $\hat{\gamma}$ are the estimated incremental outcomes (measured in SC- or H-QALYs) and costs from regression (1) and (2), respectively, and λ is the opportunity cost or threshold of the sector under analysis. The INHB captures the overall social care or health gain of an in-house VR service user compared to a contracted-out VR service user. This measures the difference between the social care or health benefits to a user of in-house VR services compared to a user of contracted-out VR services ($\hat{\beta}$) and the effect on SC- or H-QALYs to an individual, on average, due to changes in resource use if in-house VR services were used ($\hat{\gamma}/\lambda$). This effect on SC- or H-QALYs is considered to be worthwhile if in-house VR services reduces costs compared to contracted-out VR services (i.e., if $\hat{\gamma} < 0$), and assuming that the savings generated could be used at productivity levels λ to improve SC- or H-QALYs of the average individual. In contrast, this effect will be considered detrimental if in-house VR services require more resources compared to contracted-out VR services (i.e., if $\hat{\gamma} > 0$) at additional cost with equivalent reductions in resources available to utilise for other services which could increase SC- or H-QALYs of the average individual at productivity levels λ. Therefore, for a given λ, a positive INHB implies that in-house VR services are cost-effective compared to contracted-out VR services, while a negative INHB implies suggested that contracted-out VR services are cost-effective. We calculated the probability of cost-effectiveness for multiple values of λ including the health care sector λ of £13,000 (Claxton et al., 2015), and £20,000 and £30,000 per QALY (National Institute for Health Care Excellence, 2018).[4] A cost-effectiveness plane was used to illustrate graphically the uncertainty associated with the pair of estimates $\hat{\beta}$ from regression (1) and $\hat{\gamma}$ from regression (2). Uncertainty was estimated parametrically assuming that $\hat{\beta}$ and $\hat{\gamma}$ had a multivariate normal distribution. Following Briggs et al. (2006: 95), all estimated parameters in the outcome and cost regression were correlated and 10,000 random draws for both $\hat{\beta}$ and $\hat{\gamma}$ were generated. Finally, the probability of cost-effectiveness was represented graphically with a cost-effectiveness acceptability curve for a range of λ between £0 and £100,000 per QALY.

2.5.4. Sensitivity analysis

To test the robustness of the results, the analyses were re-run, testing alternative assumptions of the missing data mechanism (Carpenter and Kenward, 2012). First, complete case analysis (CCA) was used which assumes that data were missing completely at random (MCAR). Second, the data were assumed missing not at random (MNAR), that is, the probability that some information was missing depended on the underlying unobserved value even after taking into account the observed data. To identify under which conditions the results might change, multiple MNAR scenarios were examined: first, the data was imputed as above; second, the value of the imputed outcomes and costs were increased, then decreased, up to the point where the results changed. This generated nine MNAR scenarios: the imputed outcome was decreased for (a) in-house and contracted-out VR users, (b) in-house VR users only, and (c) contracted-out VR users only; the imputed costs were increased for (d) in-house and contracted-out VR users, (e) in-house VR users only, and (f) contracted-out VR users only; and the imputed outcome was reduced and the imputed costs increased for (g) in-house and contracted-out VR users, (h) in-house VR users only, and (i) contracted-out VR users only.

Using the multiply imputed data (i.e., under the MAR assumption), a number of additional sensitivity analyses were run. First, whether results changed if in-house VR unit costs were twice or half the contracted-out VR unit costs. Second, whether, under the social and health care perspective, results changed when assuming that the social care sector's threshold was double or half that of the health care sector. Third, the robustness of our estimated incremental effects to different parametric assumptions were tested by estimating outcomes and costs regressions using RE generalised linear model (GLM) with log link and gamma distribution for outcomes, and a two-part model for costs (where the first part estimated a RE logit regression and the second part estimated a linear model by RE GLM with log link and gamma distribution). Finally, subgroup analyses by age, living situation, nature of impairment and health condition were implemented.

3. Results

3.1. Descriptive statistics

In total, we recruited 233 VR users.[5] From the initial 233 VR users, three VR users were removed as they were substantially different from other VR users in terms of outcomes or costs, that is, those with social and health care costs greater than £30,000 or out-of-pocket costs greater than £4,000. On average, the sample included 13 users per VR site across 18 sites, with the number of users per site varying between three and 27. There were 113 in-house VR users and 117 contracted-out VR users. In-house VR users had on average about eight sessions in eight weeks (i.e., a session per week), and they were expected to achieve their VR goals within eleven weeks. Contracted-out VR users had on average about five sessions in five weeks (i.e., a session per week) and were expected to achieve their VR goals within less than seven weeks. In addition, compared to contracted-out VR users, in-house VR users' waiting time was on average four weeks longer. **Table 1** shows descriptive statistics on VR user characteristics at baseline in the final sample. In-house VR users had a statistically significant higher proportion of people with a mental health condition (21.2% vs. 7.7%). There was no statistical difference between the VR services on other user characteristics. **Table 2** includes descriptive statistics on LA characteristics across the 18 VR sites. Sites providing in-house VR services had a statistically significantly lower proportion (5.3%) of people who were not in deprived areas compared to sites providing contracted-out VR services, and a statistically significant higher proportion (3%) of people who were deprived in two out of five domains (where the five domains are employment, education, health and disability, and housing).

Table 3 shows the descriptive statistics on outcomes and costs for the available observations in the final sample. For all VR users, SC-QALY was on average 0.116, with in-house VR users having slightly lower SC-QALY compared to contracted-out VR users (0.116 vs 0.117). For all VR users, H-QALY was on average 0.091, with in-house VR users having greater SC-QALY compared to contracted-out VR users (0.094 vs 0.089).

Table A3 of the Appendix shows ASCOT and EQ-5D scores at each time point. Overall, social care costs and social and health care costs were on average £226 and £1,118, respectively. Table A4 of the Appendix includes detailed information on resource use. In-house VR users had greater social care costs (£232 vs. £220) compared to contracted-out VR users, and this was mostly driven by differences in VR costs and costs of other social care services including meals, befriending activity and transport. In addition, in-house VR services had greater health and social care costs (£1,259 vs. £980) compared to contracted-out VR users, which reflected higher primary (£89 vs. £65, with this difference being statistically significant at the 5% level) and secondary (£914 vs. £694) health care costs for in-house VR users. The overall standard deviation of the key outcomes and costs under analysis (i.e., SC-QALYs, H-QALYs, social care costs, and social and health care costs) were no less than 77% of the average (for SC-QALYs) indicating substantial variability across VR

Table 3: Descriptive statistics of outcomes and costs over six months.

Variable	All users										In-house			Contracted-out			In-house vs contracted-out	
	Obs	User	Mean	Standard deviation					Min	Max	User	Mean	Std err	User	Mean	Std err	95% CI of mean difference	
				Ov	User-level		LA-level											
					Btw	With	Btw	With										
Outcome																		
SC-QALYs	387	190	0.116	0.091	0.070	0.073	0.019	0.089	0.015	0.333	95	0.116	0.006	95	0.117	0.007	–0.019	0.018
H-QALYs	397	192	0.091	0.080	0.066	0.060	0.023	0.078	–0.053	0.306	94	0.094	0.006	98	0.089	0.006	–0.018	0.027
Costs (in 2017 Pound Sterling)																		
Social and health care costs	468	208	1,118	2,645	1,654	2,037	658	2,580	0	24,780	101	1,259	179	107	980	167	–301	860
Social care costs	472	208	226	546	412	378	160	533	0	5,814	101	232	32	107	220	39	–103	127
VR costs	473	208	144	403	308	269	153	388	0	5,664	101	150	21	107	139	30	–77	99
Home care costs	485	210	44	306	239	216	65	299	0	3,801	102	41	18	108	47	21	–75	63
Day centre costs	485	210	5	94	48	77	16	93	0	2,072	102	1	1	108	9	9	–25	10
Social worker costs	485	210	8	47	64	15	6	46	0	902	102	7	2	108	9	4	–9	4
Other social care costs	484	210	23	130	113	91	29	127	0	1,474	102	31	11	108	16	5	–16	46
Health care costs	480	210	875	2,471	1,543	1,910	639	2,408	0	22,708	102	1,001	171	108	752	148	–288	785
Primary care costs	484	210	77	144	97	110	31	141	0	1,618	102	89	11	108	65	7	1	47
Secondary care costs	481	210	803	2,399	1,495	1,856	614	2,340	0	22,708	102	914	164	108	694	145	–297	737

Obs = total number of observations, User = number of VR users, Ov = overall, Btw = between, With = within, Std err = standard errors, CI = confidence intervals, VR = vision rehabilitation.
Descriptive statistics were calculated using the available observations for each variable excluding three outliers as indicated in Section 3.1.

users. Moreover, both user- and LA-level between-group standard deviations were no less than 21% of the overall standard deviation, and both user- and LA-level within-group standard deviations were no less than 69% of the overall standard deviation. This suggested that there was a substantial between- and within-group variability at both user and LA level which, in turn, warranted the implementation of the panel data methods described in Section 2.5.2. The distributions of total outcomes and total costs were left-skewed and right-skewed, respectively.

3.2. Missing data

As reported in **Table 4**, the proportion of missing data for outcomes and costs was generally low at baseline varying from 0% (EQ-5D-3L score) to 4.3% (social and health care costs). The proportion of missing data increased at month 1 varying between 30.9% (EQ-5D-3L score) and 31.8% (ASCOT score), and at month 2 varying between 33.5% (EQ-5D-3L score) and 36.1% (social and health care costs). Compared to month 1 and month 2, the proportion of missing data at month 6 was slightly lower varying between 25.3% (ASCOT score) and 27.9% (social and health care costs). Table A5 in the Appendix shows that the proportion of missing data for user characteristics was low varying from 0% (gender, nature of impairment, and other health conditions) to 11.2% (previous use of VR). Moreover, in the CCA sample used in the sensitivity analysis, the proportion of missing data further increased varying from 64.8% (EQ-5D-3L score) to 69.1% (social and health care costs). **Table 5** shows the reasons for the missing data. Finally, as reported in Table A6 in the Appendix, users with complete data were statistically different from users with incomplete data in terms of age, acquired and unknown impairment, physical, sensory and unknown condition, and visual impairment registration status. This implies that the MCAR assumption might not hold true and, in turn, this warrants the multiple imputation (MI) analysis under the MAR assumption.

3.3. Cost-effectiveness results

Table 6 reports the incremental effects on outcomes and costs estimated under the MAR assumption (i.e., using the multiply imputed data). In-house VR users had, on average, 0.001 more SC-QALYs and 0.029 more H-QALYs by compared to contracted-out VR services. From the social care perspective, in-house VR users cost £1,792 less, on average. From the social and health care perspective, they cost £3,897 more.[6] These differences, however, were statistically insignificant.

Table 7 shows the estimates of the INHB for multiple values of the threshold, i.e., £13,000, £20,000, and £30,000 per SC- or H-QALY. Under the social care perspective, the average INHB was positive for all values of the threshold. The 95% confidence intervals associated with positive values of the INHB, however, suggested that the INHB was never statistically different from zero (at the

Table 4: Missing data for outcomes and costs.

Variable	Baseline		Month 1		Month 2		Month 6		CCA		
	Miss	Resp	Miss	Resp	Miss	Resp	Miss	Resp	Miss	User	Obs
Outcome											
ASCOT score	1.7%	229	31.8%	159	35.2%	151	25.3%	174	66.5%	78	234
EQ-5D-3L score	0.0%	233	30.9%	161	33.5%	155	26.2%	172	64.8%	82	246
Costs											
Social care	3.0%	226	31.3%	160	35.6%	150	26.6%	171	67.4%	76	228
Social and health care	4.3%	223	31.3%	160	36.1%	149	27.9%	168	69.1%	72	216

CCA = complete case analysis, Miss = proportion of missing responses, Resp = number of respondents, User = number of VR users, Obs = total number of observations (=number of VR users × 3 time points).

Table 5: Reasons for missing data.

Reason for missing data	Baseline		Month one		Month two		Month six	
	Prop	User	Prop	User	Prop	User	Prop	User
Users not reached	0.0%	0	30.0%	70	32.6%	76	26.6%	62
Missed calls	0.0%	0	7.3%	17	9.0%	21	16.3%	38
Unwilling to respond	0.0%	0	6.9%	16	8.2%	19	9.0%	21
Not contactable	0.0%	0	15.9%	37	15.5%	36	0.0%	0
Dead	0.0%	0	0.0%	0	0.0%	0	1.3%	3
Users who responded	100.0%	233	70.0%	163	67.4%	157	73.4%	171
Total amount of users	100.0%	233	100.0%	233	100.0%	233	100.0%	233

Prop = proportion, User = number of VR users, Not contactable = users who could not be reached due to interviewers' sickness absence.

Table 6: Incremental effect on outcomes and costs for in-house versus contracted-out VR services.

Variable	Obs	User	Δ	SE	95% CI	
Outcome						
SC-QALYs	690	230	0.001	0.018	–0.035	0.037
H-QALYs	690	230	0.029	0.021	–0.014	0.072
Costs (£)						
Social care costs	690	230	–1,792	1,077	–3,914	329
Social and health care costs	690	230	3,897	4,531	–5,037	12,830

Obs = total number of observations; User = number of VR users, Δ = incremental effect of in-house vs contracted-out VR services over the six months under analysis, i.e. $\hat{\beta} \times 3$ in regression (1) for outcomes and $\hat{\gamma} \times 3$ in regression (2) for costs; SE = standard error; CI = confidence intervals.
Analysis conducted under the MAR assumption.
User covariates: VR type dummy, baseline outcome/costs, age dummy, gender dummy, ethnicity dummy, living situation dummy, nature of impairment dummies, other health conditions dummies, vision impairment status dummies, previous use of VR dummy.
LA covariates: total population, population density, proportion of people aged 65 and over, proportion of people deprived variables, type of LA dummies.
Standard errors were clustered at the user level.

Table 7: Incremental net health benefit and probability of cost-effectiveness for in-house vs contracted out VR services.

Perspective	λ = £13,000 per QALY				λ = £20,000 per QALY				λ = £30,000 per QALY			
	INHB	95% CI		Prob	INHB	95% CI		Prob	INHB	95% CI		Prob
Social care	0.139	–0.027	0.305	94%	0.091	–0.021	0.202	94%	0.061	–0.018	0.140	93%
Social and health care												
Using SC-QALYs	–0.299	–0.983	0.385	18%	–0.194	–0.639	0.252	19%	–0.129	–0.427	0.169	19%
Using H-QALYs	–0.271	–0.955	0.414	21%	–0.166	–0.612	0.280	23%	–0.101	–0.400	0.198	25%

λ = marginal productivity; INHB = incremental net health benefit; CI = confidence intervals; Prob = Probability of in-house VR services being cost-effective.
Analysis conducted under the MAR assumption.

5% level). In addition, under the social care perspective, the probability of cost-effectiveness varied between 93% and 94%. The top and bottom of **Figure 1** shows the cost-effectiveness plane and the cost-effectiveness acceptability curve, respectively. The probability that in-house VR services were cost-effective compared to contracted-out VR services ranged between 93% for a zero-threshold and 80% for a threshold of £100,000 per SC-QALY.

Under the social and health care perspective, the INHB was negative for all values of the threshold for both SC- and H-QALYs. Also in this case, confidence intervals suggested that the INHB was never statistically different from zero (at the 5% level). As pictured in **Figure 2**, the probability of cost-effectiveness for the in-house VR service ranged between 18% and 22% when considering SC-QALYs, and between 19% and 42% when considering H-QALYs. The results of the sensitivity analysis are discussed in Section A2 of the Appendix.

4. Discussion

To our knowledge, this is the first study that has undertaken a cost-effectiveness analysis of in-house versus contracted-out provision of VR services. The analysis aimed to inform decision makers from a social care and a social and health care perspective. Findings showed that, for a threshold between £13,000 and £30,000 per QALY, in-house VR services have a high probability (about 90% vs. contracted-out VR services) of being cost-effective under a social care perspective. This might be because in-house VR services cover a broader range of rehabilitation activities and link VR users with other LA services more easily. In turn, better links with other LA services might produce a better assessment of need allowing more tailored interventions and a more effective and efficient use of LA resources. Under a social and health care perspective, however, in-house VR services have a much lower probability (about 25% vs. contracted-out VR services) of being cost-effective. We conjecture that a better assessment of needs for users of in-house VR services might also make them more aware of their underlying health conditions (e.g., early symptoms of dementia) increasing their demand for health care services. Indeed, our findings indicate that users of in-house VR services tend to use more hospital services. This suggests that better coordination (or integration) between LA and NHS services might offer larger cost savings and better outcomes for the public sector.

This study contributes to the international literature on the economic evaluation of VR services. Rabiee et al. (2016: 250) suggest that UK in-house VR services may have characteristics in common with those in other countries where VR services feature a multidisciplinary approach. For example, recent guidelines in the US (Fontenot et

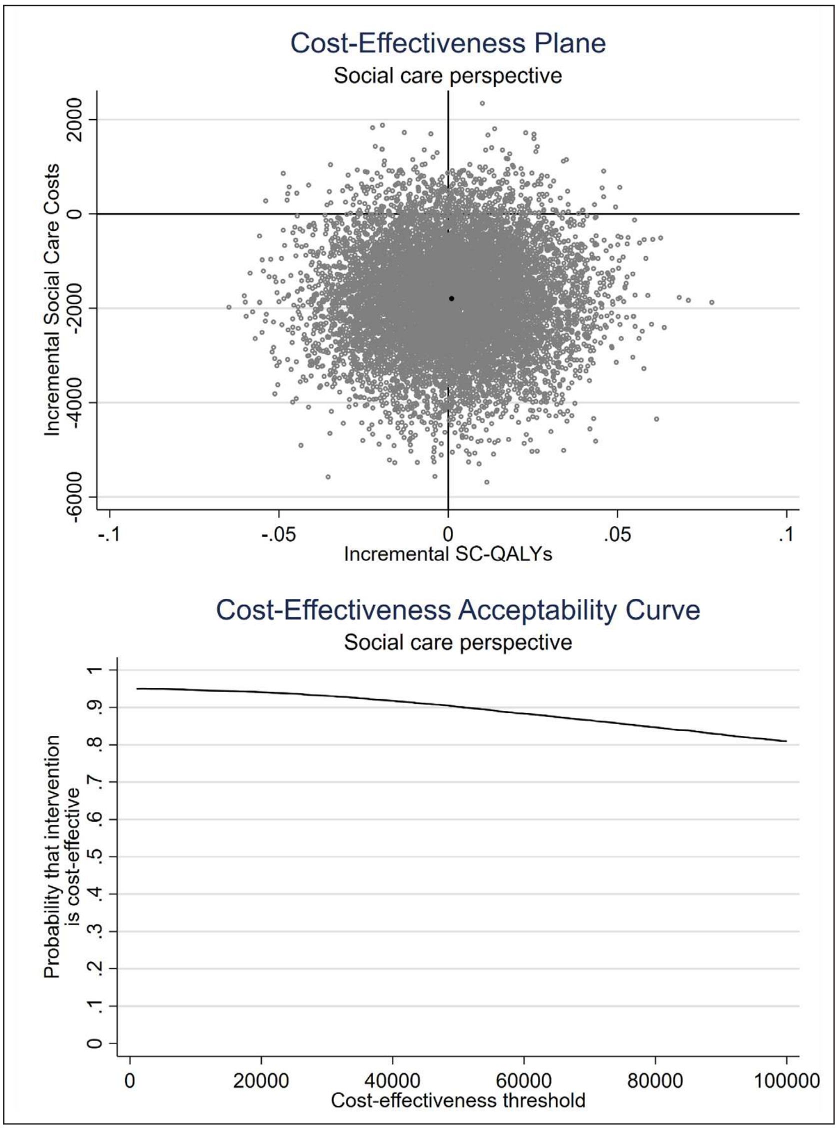

Figure 1: Cost-effectiveness plane and acceptability curve under the social care perspective.

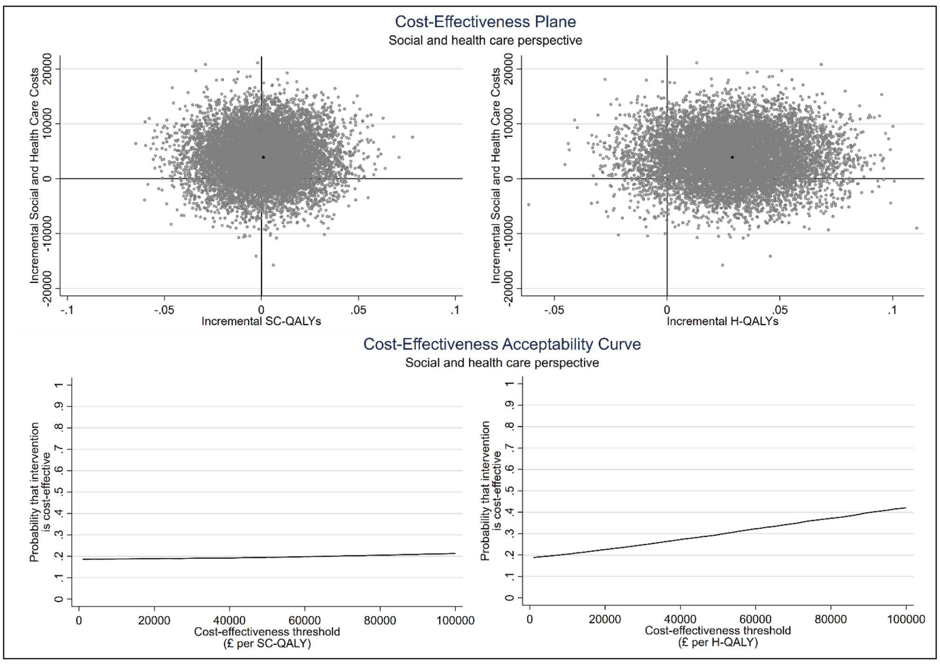

Figure 2: Cost-effectiveness plane and acceptability curve under the integrated care perspective.

al., 2018) highlighted the importance of referring visually impaired individuals to multidisciplinary VR services. Such services aim to address the broader impact of vision loss on patients' lives (e.g., by optimising activities of daily living, safety, and social life) in addition to improve their visual ability. Also studies on VR in other countries, such as Australia (e.g. Rees et al., 2013) and Netherlands (e.g. Alma et al., 2012), highlight the necessity to integrate social and health care VR services through a multidisciplinary approach. In general, our findings are relevant to all those countries providing community-based VR services or a mix of clinic- and community-based VR services.

The current study has some limitations. The gold standard design for cost-effectiveness studies is the randomised controlled trial, which offers the best potential to estimate unbiased intervention effects on outcomes and costs. In this context, however, the large majority of LAs across England already provide VR services, therefore it was not possible to obtain a no VR comparator. Although observational studies are prone to selection bias due to confounding, econometric techniques based on selection on observables were used to control for several user and LA characteristics to reduce the risk of bias. However, unobserved factors may still bias the results. For example, differences in the proportion of users with mental health problems across in-house and contracted-out VR services might suggest that these models serve populations that differ on certain unobserved aspects. To reduce the risk of selection bias further, future observational studies on VR services could consider whether econometric methods based on selection on unobservables (e.g., instrumental variables, difference-in-difference) would be useful. In addition, the proportion of missing data was not irrelevant in this study. We ran the MI analysis and the MAR assumption to address these concerns, but our results incorporate greater uncertainty because the true missing data mechanism remains unknown. Finally, the survey sample used in this study was powered using the VFQ score rather than the outcomes or costs used in the economic evaluation and, therefore, differential effects for these variables might be too small to be statistically detected.

We investigated the cost-effectiveness of the two VR service models under a social and health care perspective rather than a societal perspective. The societal perspective is commonly employed in cost-effectiveness studies in order to account for all possible relevant resources in the economy, although it is unclear who the societal decision maker is. If a societal perspective had been taken, multiple assumptions would have been required. For example, it would have been important to handle differing thresholds across sectors to compute a single cost-effectiveness indicator. Therefore, we used a narrower social and health care perspective as this perspective has relevance to LAs integrated with the NHS. A note of caution about the social and health care perspective is that none of the recruited LAs were fully integrated within the NHS. The results provide insight for informing decision makers; however, it remains unclear as to how these results might transfer across to providers of fully integrated social and health care services. In conclusion, these limitations suggest that our findings should be interpreted with caution and that further research on this aspect of VR services might be relevant.

Additional File

The additional file for this article can be found as follows:

- **Appendix.** The Appendix includes additional information on outcomes (Section A1) and sensitivity analysis (Section A2, Table A7–A12 and Figure A1). Moreover, it includes more details on unit costs (Table A1), the imputation model (Table A2), and descriptive statistics (Table A3–A6). DOI: https://doi.org/10.31389/jltc.26.s1

Notes

1. Some equipment may be paid for by some users.
2. More precisely, α_i, ω_i, κ_j and ψ_j are independent and identically distributed random variables with zero-mean and constant variance. These variables are capturing unobserved factors at user (α_i and ω_i) or LA (κ_j and ψ_j) level impacting the dependent variable and that do not vary over time (Cameron and Trivedi, 2009: 700). For example, each user's genetic makeup is unobserved but may have an impact on social and health care outcomes. Similarly, the sense of community of the LA's population may have an effect on social and health care outcomes.
3. Our panel data approach and the cross-sectional ordinary least square (OLS) approach analysing the total QALY, calculated over the whole six-month period under analysis, would produce identical results under the assumption of homoscedasticity. The cross-sectional approach, however, is likely to estimate biased standard errors in the presence of autocorrelation over time which, instead, can be taken into account in the panel data model.
4. At present, there is no official guidance on the opportunity costs threshold to use when evaluating social care interventions. We therefore employ the thresholds that are generally used in the health care sector as suggested by NICE (National Institute for Health Care Excellence, 2018) or other studies in this field (Claxton et al., 2015).
5. We carried out the calculation of the minimal detectable effect size before conducting the survey using the National Eye Institute Visual Function Questionnaire (or VFQ for short), which is a condition specific instrument for measuring outcomes in people with vision impairment. At the available sample size of 230 VR users, we could detect an effect of 0.44 standard deviations difference between in-house and contracted-out VR services on the VFQ scale (ranging from zero for dead to 100 for full health). Using the unweighted VFQ score as an outcome, the estimated incremental effect of in-house vs. contracted-out VR was –0.879 (i.e., 13% of the average) with a standard error of 1.833, that is, the effect size was 0.48 (= 0.879 ÷ 1.833), which is larger than the minimal detectable effect size of 0.44.

[6] From the social and health care perspective, higher costs for in-house VR users compared to contracted-out VR users are driven by hospital costs.

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Competing Interests
The authors have no competing interests to declare.

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